

2/10/05

10/536567

JC13 Rec'd PCT/PTO 26 MAY 2005
33997.0115

Express Mail Label No. ER 951276976 US

English Translation of International App. No. PCT/EP2003/013493

APPARATUS FOR REFLECTING OUT A STEREOSCOPIC OBSERVATION BEAM PATH

The invention concerns an apparatus for reflecting at least one stereoscopic observation beam path out of a microscope, for example a surgical stereomicroscope.

5 In neurosurgery and ophthalmology, it is desirable for two equally qualified operators (surgeon and assistant) to be able to follow surgical occurrences under the microscope. From a very early date, numerous possibilities have already been offered for combining two microscopes with one another:

10 German Examined Application DE-AS 1 217 099 discloses, in a number of variants, a stereomicroscopic device which comprises at least two stereomicroscopes M_1 and M_2 having a shared subject plane, and which permits simultaneous observation of the surgical field by two or more persons. In such devices, a combination of reflectors (splitter prisms) ensures that the axes of the individual observation beam paths between objective and subject coincide. The reason
15 such microscopes have not proven successful on the market is because, as shown in Fig. 1 of this publication, the splitter prism is arranged beneath main objectives O_1 and O_2 of microscopes M_1 and M_2 , and results there in an astigmatism in the convergent beam path that is not correctable because of the rotation of microscope M_2 around M_1 . As variant embodiments thereof, Figures are depicted in this Examined
20 Application in which the splitter prism is located above main objective O_H . It is disadvantageous in this context that the beam path is extremely long and thus results in further optically necessary corrective actions, for example for pupil location. Combinations of deflection elements, as proposed in Fig. 2 through Fig. 7 of DE-AS 1 217 099, lead to unavoidable vignetting because of the long glass paths. With this
25 principle of combining two vertically configured microscopes parallel to one axis, the overall height is moreover very large. This results in ergonomic disadvantages that are very significant especially in the context of surgical microscopes.

It has been possible to eliminate some of these disadvantages (cf. documents DE-C2 33 33 471 and US 4,605,287). For example, the beam splitter has
30 been replaced by a thin splitter plate in the convergent beam path beneath the main

objective. Astigmatism is thereby avoided, but bothersome double images are produced. One embodiment is described in the Leica brochure "0° assistant's microscope, stereo – For assisting and training in ophthalmology," document no. M1-665-0en, publication annotation VI.98 (June 1998).

5 Another approach is presented in DE-C2 43 31 635. In this special microscope for ophthalmology, the beam splitter element is arranged above the shared main objective. To reduce the overall height, a particularly low deflection element was designed that nevertheless allows mechanical, but not optical, rotation of the assistant's microscope around the main microscope. The only capability that therefore
10 exists is that of using the assistant's microscope exclusively to the right or left of the main microscope. Use of this system is thereby confined to ophthalmology, and it is not sufficiently usable in neurosurgery. This is because in neurosurgery it is necessary for the assistant's microscope to be continuously pivotable, mechanically and optically, around the main microscope. In general, this microscope has the advantage
15 that no astigmatism occurs; there are also no double images produced, and the overall height is sufficiently low.

 DE-A1-195 41 420 describes a microscope in which the illumination device can be arranged in at least two positions relative to the main microscope. For example, a reflecting-out system for an assistant's microscope is described, that
20 system being arranged rotatably about the axis of the main microscope and between the objective and that main microscope. In the system described, this results in a large and ergonomically unfavorable overall height, as well as vignetting and reflections that are bothersome to the observer.

 US-A1-2001/0010592, on the other hand, describes a microscope in which
25 a horizontally located two-channel zoom system is proposed in order to reduce the overall height. A beam splitter is arranged with the assistant's microscope beneath the main objective. As a result, an interface is available from which the assistant's microscope can selectably be removed. One disadvantageous consequence, however, is that each microscope requires its own main objective, which optionally must be
30 electromechanically coupled to one another. Usability is also limited because no rotation is possible. Because the illumination beam path also passes through the beam

splitter of the assistant's microscope, reflections occur there that are extremely difficult to eliminate. The observation beam path passes divergently through this beam splitter, thus resulting in troublesome vignetting. An additional consequence of this arrangement of the beam splitter is an astigmatism that depends on the orientation of the assistant's microscope relative to the main microscope.

It is thus the object of the present invention to create an apparatus with which at least one stereoscopic observation beam path for an assistant's microscope can be reflected out in optically and mechanically continuously rotatable fashion, while avoiding all the aforementioned disadvantages.

This object is achieved in that a beam splitter for reflecting out the assistant's stereoscopic observation beam paths is arranged between the main objective and the zoom of the main microscope and is continuously rotatable, together with the assistant's microscope, about the optical axis of the main microscope, and is thus optically usable in any rotational position. "Continuously rotatable" is understood to mean a rotation about the optical axis of the main objective that makes possible any rotation angle about the axis, steplessly and/or in steps. In order to decrease the overall height of the main microscope, the arrangement of the beam splitter is combined, according to the present invention, with a zoom whose axis deviates from the optical axis of the microscope. This zoom comprises two optical systems of identical type that are preferably located perpendicular to the optical axis of the main objective. There is therefore a zoom in each stereoscopic partial beam path.

Further embodiments represent, for example, obliquely located, non-parallel optical channels in the zoom.

The beam splitter can effect geometric or physical beam splitting and can be embodied as a splitter cube, splitter plate, or pellicle, or can even comprise an LCD element.

As a result of the arrangement of the beam splitter between the main objective and the zoom, all the optically necessary corrections can be performed, or are in fact have no cause to be needed, since no astigmatism, no double images, no reflections resulting from the illumination, and no vignetting occur. Furthermore, the main observation beam paths and the assistant's observation beam paths pass through

the shared main objective, with the additional advantageous consequence that a separate objective for the assistant's microscope, with an electromagnetic coupling to the main objective, is not necessary.

5 As a further embodiment, the assistant's microscope can be removed from the microscope by way of a mechanical detachment point. As a variant of this, the assistant's microscope can be selectably removed from the main microscope with or without the beam splitter.

10 The assistant's microscope can furthermore contain, in the region between the beam splitter and the deflection element, optical components (spherical and/or plane optics) that make it possible to modify this aforesaid spacing between the beam splitter and deflection element. If the deflection element is designed rotatably through an angle relative to the beam splitter about the axis of the assistant's microscope, there is then room in the region between beam splitter and deflection element for optical image reversal elements, for example Dove prisms.

15 The main objective that is used in shared fashion can be designed for a fixed or a variable focal length. In particular in the context of a variable focal length for the main objective, it is useful to guide the illumination through the main objective, i.e. to arrange it between the main objective and the splitter prism. This automatically ensures that the illuminated field is always in the correct location and is
20 correlated with the size of the subject field. The overall height is, however, disadvantageously increased. To prevent this, it is advisable to use the "Objective with illumination" described in the German Patent Application bearing the official application no. 102 35 706.4. This main objective, used in shared fashion by the main and assistant's observation beam paths as well as the illumination beam path, is
25 separated into one objective part for observation and a second objective part for illumination, the objective part for illumination being removed from the main objective and arranged at an angle to the optical axis of the main objective.

The "Objective with illumination" described above can be selectably rotated about the optical axis of the main objective.

30 The present invention is described below in more detail with reference to the Figures.

The Figures are described in interconnected and overlapping fashion. Identical reference characters denote identical components; reference characters with different indices indicate functionally identical components.

In schematic fashion,

- 5 FIG. 1 shows, in a side view, the overall configuration of a reflecting-out apparatus according to the present invention; and
- FIG. 2 shows, in a plan view, a detail of the apparatus depicted in FIG. 1 having a rotatable beam splitter.

FIG. 1 depicts: a main microscope 1, with a surgeon as main observer H,
 10 having a main objective 2 with a vertical optical axis 4; a subject 3; and an assistant's microscope 8 for an assistant A. An illumination beam path 12a having an axis 12, proceeding from a light source 16, is projected through a deflection element 13 onto a subject 3 (e.g. a patient). Subject 3 is imaged by way of stereoscopic main observation beam paths 4a, b, via a main objective 2, a beam splitter 7, and a further deflection
 15 element 5, into a horizontally located zoom 6.

As a consequence of the side view of main microscope 1, only one 4a of the two stereoscopic main observation beam paths 4a, b, one 9a of the two assistant's observation beam paths 9a, 9b, and one of the two zooms 6 of identical type, are visible in FIG. 1. The manner of operation of the main and assistant's observation
 20 beam paths 4a, 9a, as described below, is also analogously applicable to observation beam paths 4b, 9b.

Further components that are important for the operation of the microscope, such as the binocular tube and eyepieces, are not depicted in this Figure in the interest of simplicity.

25 Beam splitter 7 splits main observation beam path 4a into two partial beam paths. Beam splitter 7 sends the one partial beam path on as main observation beam path 4a. The other partial beam path is reflected by beam splitter 7 out of main observation beam path 4a as assistant's observation beam path 9a. This assistant's observation beam path 9a is directed via a further deflection element 10 into a
 30 binocular tube with eyepieces (not depicted in this Figure in the interest of simplicity). As a result of its arrangement, this deflection element 10 makes possible a tilting and

thus a deflection, through a modifiable angle equal to a magnitude α , of observation beams 9a, b for assistant A.

5 The binocular tube (not depicted) can be arranged rotatably about an optical axis 9, lying between assistant's observation beam paths 9a and 9b, of assistant's microscope 8, and can thus enable a rotation through angle β of assistant's observation beam paths 9a, b.

Assistant's microscope 8 can be, for example, detachable from main microscope 1 at a mechanical detachment point 11.

10 A spacing variation 15 indicates the possibility of varying the spacing between beam splitter 7 and deflection element 10. The possibility additionally exists of rotating deflection element 10 relative to beam splitter 7, through an angle θ , about an axis 14 that lies between the two assistant's observation beam paths 9a, b.

15 FIG. 2 illustrates a rotation γ of beam splitter 7 that is accomplished continuously about optical axis 4 of main objective 2. Also depicted are main observation beam paths 4a, b, as well as assistant's observation beam paths 9a, b. The outline of main objective 2 is visible as a projection into the plane of beam splitter 7. According to the present invention, beam splitter 7 is rotated together with assistant's microscope 8 (not depicted in this Figure).

PARTS LIST

| | | |
|----|----------|---|
| | 1 | Main microscope for (H) |
| | 2 | Main objective |
| | 3 | Subject (illuminated field) |
| 5 | 4 | Optical axis of (2) |
| | 4a, b | Main observation beam path |
| | 5 | Deflection element for (4a, b) |
| | 6 | Zoom |
| | 7 | Beam splitter |
| 10 | 8 | Assistant's microscope for (A) |
| | 9 | Optical axis of (8) |
| | 9a, b | Assistant's observation beam path for (A) |
| | 10 | Deflection element for (9a, b) |
| | 11 | Mechanical detachment point |
| 15 | 12 | Axis of (12a) |
| | 12a | Illumination beam path |
| | 13 | Deflection element for (12a) |
| | 14 | Horizontal axis of (8) |
| | 15 | Spacing variation between (7) and (10) |
| 20 | 16 | Light source |
| | α | Tilt of (10) |
| | β | Rotation of (9a, b) |
| | γ | Rotation of (7) |
| | θ | Rotation angle about (14) |
| 25 | A | Assistant |
| | B | Main observer (surgeon) |